

**The Concept of Health in One Health and Some Practical Implications for Research and Education: What Is One Health?**

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**ABSTRACT**

*From a strict biological point of view, humans are just one species among other species, albeit one with very special capacities, characteristics, and skills. Among scientists, it is generally acknowledged that we share many features with other animal species, which are certainly relevant when the concepts of health and disease are discussed. The term 'One Health' is used in many different contexts and by people with varying backgrounds. However, there appears to be some confusion as to what the term really means, and it is used in a wide range of contexts, often including or bordering concepts such as infection biology, contagious diseases, zoonotic infections, evolutionary medicine, comparative medicine, and translational medicine. Without claiming to present the one and only true interpretation, we will argue for a wide approach using the 'umbrella' depiction developed by One Health Sweden. We argue that this one should, compared to other demarcations, be more useful to science. We will also analyze the concept of health on different levels: individual, population, and ecosystem health, and describe how these levels inherently influence each other for both humans and animals. Both these choices are normative and have practical consequences for research and education, a way of reasoning which we develop further in this paper. Finally, we conclude that the choice of term for the approach might be normative in deciding which disciplines or parts of disciplines that may be included.*

**KEYWORDS: Health, Definition, One Health, Concept, Implications for Practice**

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**Introduction**

The perspective of One Health, at least considering practical regulations with the aim of improving or safeguarding animal and human health, has been traced back to ancient times. One early record is from the Fourteen Rock Edicts (stones with regulations placed near roads) from the reign of King Ashoka (ca. 304 BC–232 BC) in India: everywhere has Beloved-of-the-Gods, King Piyadasi, made provision for two types of medical treatment: medical treatment for humans and medical treatment for animals. Wherever medical herbs suitable for humans or animals are not available, I have had them imported and grown. Wherever medical roots or fruits are not

available I have had them imported and grown. Along roads I have had wells dug and trees planted for the benefit of humans and animals (Dhammika, 1993).

The theoretical foundations of such a One Health approach (a philosophy of One Health) have received limited discussion during history. Still, there are a few scientists who have actually taken time to do this kind of research and among those one could mention, for example, Rudolf Virchow (1821–1902), a physician, and Calvin W. Schwabe (1927–2006), a veterinarian (Lerner, 2013). This paper will, however, not primarily deal with these historical discussions but rather present some modern thoughts on One Health, gathered from the ongoing discussion within philosophy of medicine and philosophy of veterinary medicine.

As a starting point, we will use the symbolic ‘umbrella’ recently developed by One Health Sweden in cooperation with the One Health Initiative Autonomous pro bono team, which tries to encompass all relevant aspects of the One Health movement. In this paper, we will analyze some aspects of the three center green circles of health. A number of scientific fields are present under the umbrella of One Health (see the top row circles): biology, human medicine, veterinary medicine, public health, environmental chemistry, and health economy, to mention some of the most important ones. Here, our discussion will in particular relate to public health, veterinary medicine, human medicine, and ecology. We will also discuss both research and education – issues not explicitly highlighted in the umbrella picture but considered implicit for all segments and topics of the whole picture.

The ‘One Health Umbrella’ developed by the networks ‘One Health Sweden’ and ‘One Health Initiative’ to illustrate the scope of the ‘One Health concept’.

The paper will deal with these four topics:

1.	The demarcation of One Health (top row circles)
2.	The concept of health (center green circles)
3.	Practical consequences for research
4.	Practical consequences for education

### **The Demarcation of One Health**

For a demarcation of One Health, our initial starting point is the symbolic umbrella developed by One Health Sweden in cooperation with the One Health Initiative autonomous pro bono team. According to this umbrella, One Health is a wide encompassing field where several disciplines could contribute. For a number of different examples of current definitions – if not demarcations – of One Health provided by different international organizations in the field, please see Gibbs (Gibbs, 2014).

Other terms have also been used for similar purposes. We therefore need to dwell a little on the different terms used to demarcate the area, terms that sometimes are perceived as more or less synonymous with One Health. These are:

1.	One medicine
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2.	Comparative medicine
3.	Translational medicine
4.	Zoobiquity
5.	Evolutionary medicine

Some authors consider the terms ‘One Medicine’, ‘One Health’ and ‘One World, One Health, One Medicine’ to be entirely synonymous (Gibbs, 2009). We will here argue that there might be a difference between them that is crucial.

Whereas the term One Medicine is mainly, although not exclusively, used in relation to transmissible or contagious zoonotic diseases, there are of course other health aspects that humans and other animal species have in common. In many cases, animals have been used as models for human diseases, and in some cases the knowledge about certain diseases or syndromes has also been transferred back to certain species of animals. This phenomenon is often referred to as ‘comparative medicine’. The shift from One Medicine to One Health partly reflects this mental shift to a broader perspective, covering not only infectious diseases but also general public health issues, comparative medicine, and ecology.

Comparative medicine is, by definition, based on the idea of comparing humans to one or more chosen animal species, or the other way around. Hence, it has limitations from a veterinary point of view, as veterinarians are also often interested in comparing different animal species with each other, that is, making comparisons that include several different species but not necessarily always including *Homo sapiens*. In the context of One Health the term ‘translational medicine’ is sometimes mentioned as well. The term is then used to illustrate how different knowledge in basic scientific disciplines can be ‘translated’ into new or improved therapies, procedures, diagnostic tools, or policies for individuals and populations. Translational medicine can certainly be regarded as a relevant aspect of One Health, the difference being that One Health stands for a truly multi- and interdisciplinary approach, that is, a much wider concept.

Recently, yet another term has been launched to illustrate the fact that humans and animals in many cases develop the same or similar health problems: ‘zoobiquity’ (Natterson-Horowitz, 2013). The authors introducing this term argue that One Health is one-sided, as they perceive it as based on human medicine using insights of veterinary medicine, and not the other way around. We disregard this view. What they argue for is a ‘new fusion of veterinary, human and evolutionary medicine’. Furthermore, they claim: ‘We can treat the shared diseases of all animals, including humans, by taking a multispecies – that is, zoobiquitous – approach in our daily practices’. The aim is again to apply a species-spanning approach to medicine, this time encompassing not only contagious diseases (infections) or other types of physical diseases (such as cancer or metabolic diseases) but also mental health, including anything from behavioral problems to addictions or depressions. One of the aims is nevertheless to integrate human and veterinary medicine and biology into an interdisciplinary approach.

‘Evolutionary medicine’ is an attempt to adopt biological ideas of macro- and microevolution, fitness and environment to medical thinking (Gluckman, 2009). Further, the advocates of evolutionary medicine seem to argue that one has to take longer timescales into consideration when thinking about health matters (Gluckman, 2009, Steams, 2007). Evolutionary medicine is

then a framework explaining and contributing to the discussions of health as well as the environment from the field of biology. In the version presented by Natterson-Horowitz and Bowers (Natterson-Horowitz, 2013), evolution is used to explain that some diseases have common ancestry and have existed for a long time (for example, cancer, which is traced back to dinosaurs). However, evolutionary medicine in other cases appears to be highly focused on humans and human health and disease, that is, with a surprisingly strict anthropological approach (Trevathan, 1995 and Ruhli, 2013). We could therefore argue that the One Health concept is wider than zoonosis, as there is no problem to include an evolutionary approach within the One Health concept.

As a conclusion, we argue that One Health is a wider concept than all the other concepts mentioned above (One Medicine, comparative medicine, translational medicine, zoonosis, and evolutionary medicine). One Health could be used as an encompassing term to all these other concepts.

### The Concept of Health

The concept of health could be defined on at least three different levels: the individual level, the group or population level, or the ecosystem level. At the first level, two concepts are used: animal health and human health. There is an ongoing discussion both in animal ethics and in philosophy of medicine on how to look at animals. The term ‘non-human animals’, referring to all animal species except *Homo sapiens*, has been used for decades (Bekoff, 1994) and is becoming increasingly common not only within animal rights groups but also in everyday colloquial usage and in scientific literature, a shift which certainly has normative connotations. The reason as to why separate humans from animals and not animals from animals is a highly normative issue. The animal kingdom shows a huge variety of life forms and to lump them together as a unity seems questionable (Derrida and Lerner, 2008). This seems especially true when it comes to the aspect of mental health (Lerner, 2008). Another possibility that would be fruitful for One Health is to find a definition of health that is applicable to all animals including humans.

On the second level, the population level, at least two concepts might be used. In human medicine one can use public health. In veterinary medicine and biology, the terms herd health or population health could be used but for simplicity reasons; we here call it population health regardless of the species involved.

On the third level among several possible terms, we use ecosystem health. This gives us the scheme below:

1.	<b>Individual level of health</b>		
		a.	Animal health
		b.	Human health
2.	<b>Population level of health</b>		
		a.	Population health
		b.	Public health
3.	<b>Ecosystem level of health</b>		

		a.	Ecosystem health
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We will here initiate an analysis of the concept of health at these three levels and we will start at the individual level.

The concept of human health has been thoroughly discussed within philosophy of medicine since the 1970s. Several categories of health definitions have been developed ranging from merely physiological interpretations to more holistic, including mental and/or social well-being (Nordenfelt, 2006).

The concept of animal health has been less discussed, although several categories of health definitions have been presented (Lerner, 2008, Gunnarsson, 2006). These also range from physiological to more holistic. Still, a thorough theoretical discussion of these categories is merely absent. There are also similarities in the categories of health between the two fields, which we will develop further below.

At the population level, the concept of health is more problematic. The concept herd health is mainly used in relation to monitoring, that is, focused on the surveillance of disease occurrence or patterns but can also indirectly involve aspects of safeguarding the microbiological quality of food of animal origin, that is, food safety (Krebs, 2001). The first aspect is true also for human public health. It can, of course, be argued that both humans and one or more non-human animal species in many cases belong to the same multispecies population. This is particularly obvious in the case of zoonotic diseases where several species, including humans, are susceptible to infections by the same pathogen microorganisms. It is certainly valid also for a variety of other types of diseases, such as syndromes caused by environmental contamination with toxic agents, affecting both humans and animals that will then, from an epidemiological perspective, belong to a larger target population.

In these cases, the concept of health also bears a statistical component. Questions formulated here are: Is the disease absent, present, or is this even a common disease? Certain individuals within a group could be unhealthy even if the group as a whole is regarded as healthy. From a biosecurity point of view, health is often perceived as being a trait or characteristic of the group, or even a region or country. In this case, the term health merely reflects freedom from a specific transmissible disease. ‘Freedom from disease’, that is, a disease-free status, can be proven by properly designed sampling schemes and officially declared by a government or a public official, for example, to facilitate trade and travel. This aspect is, however, usually restricted to animals and animal products, that is, not applied in human medicine – at least not officially.

Still, a central argument both in theoretical discussions in human as well as animal health is that health as a concept belongs to the individual level. Lerner analyzes this further for animal health:

The claim made could further be interpreted in two ways.

1.	The concept needs to be defined so that [it] refers to the animal or the components of the animal.
2.	The concept needs to be defined so that [it] refers to the level of the animal (including the surroundings of the animal) and not to some systemic level above the animal.

A similar discussion has been present in the conflict between animal ethics and environmental ethics when it comes to ascribing values. Animal ethicists claim that inherent value only can be ascribed to individuals (humans and some animals) but not to ecosystems. This is a central distinction between the now common terms biocentrism and ecocentrism (Callicott, 1995). We will not further analyze this claim.

This implies that health at the population level such as population health or public health is rather a monitoring tool which is a statistical measure of health within a population rather than concepts of health.

On the third level of health, the ecosystem level, where the concept is ecosystem health, two ways of analyzing this concept seem to be present. Ecosystem health has been used either as a metaphor or as a defined concept of health. Definitions for ecosystem health do exist. One example of the latter is provided in Jakobsson (Jakobsson, 2012).

According to Jakobsson (Jakobsson, 2012), ecosystem health is a combined concept of ecosystem and health. Ecosystem refers to flora, fauna, other organisms, and the surrounding environment. Health 'is an important indicator of the systems' function'. 'Ecosystem health is a comprehensive and integrated approach, which reflects the health of the living and non-living components of the land and marine world'. Jakobsson recognizes that this way of looking at health is far wider than the traditional one, and it shows links between human activity, ecological change, and health. 'Health ultimately depends upon ecosystem services i.e. availability of fresh water, food, fuel, pollination etc.'

In Jakobsson's wide concept, health refers to something else than the individual or even population level. Using ecosystem health must be seen as an operational or instrumental definition (as an indicator for something). Nevertheless, the concept of ecosystem health has been widely discussed, and the perceptions of its limitations and the definition applied vary between different research groups (Rapport, 1999), also in relation to the properties of health.

Not at all mentioned above, but nevertheless important, is plant health, which could be defined both at an individual and at population level (Döring, 2012). Plant health, or more specifically the fact that contaminated plants can act as vectors for diseases that affect humans, has been identified as important within One Health (Fletcher, 2009). Furthermore, some pathogens can negatively affect the health status of all three groups; plants, animals, and humans (Fletcher, 2009). Although certainly being included in the One Health concept, plant health is often perceived as a part of ecosystem health rather than as a separate entity, to clearly differentiate between the health of sentient beings, that is, humans and animals, on one side and other health concepts on the other. However, whether this demarcation may hold need further elaboration in the future.

This analysis gives us at hand that only health at the individual level is a true concept of health, and that health at the other levels are more a tool for the surveillance of processes or states among aggregated individuals.

So far, we have only discussed demarcation aspects of health. We will now turn to possible definitions of health and especially those that might be applicable to all animals, including humans. Among health definitions present, at least three categories of definitions might be useful

in this sense: physiological (Boorse, 1997, Broom, 2004), mental (Nordenfelt, 2006), or balance theories (for a wider discussion and other categories of health that might be applicable).

Choosing a definition of health is a normative issue. Different definitions of health cover different aspects of life. A physiological definition might be applicable to most species but will not cover all the aspects that are important for human health (e.g. mental health). As an example, let us develop the idea of health as balance.

At the individual level, theories of health referring to some kind of balance have been present from ancient times till present (Lerner, 2006). The most famous have been health in terms of a humoral theory. This theory was abandoned during the 19th century in favor of better working theories, such as Rudolf Virchow's theory of health as vital cells (Lerner, 2012). More modern versions are the theories of stress, where health is seen as a proper or valid response to stressors trying to restore a balance in the body. These theories exist both in human medicine (Cannon, 1949) as well as veterinary medicine (Broom, 1993). At the population level, one could talk about populations that are in balance when it comes to population dynamics. In ecosystem research, it is also possible to use an idea of dynamic equilibrium (or balance) as a concept of ecosystem health.

The problem with balance theories, however, is that they are unable to explain states such as 'I feel better than usual' or 'I am extremely healthy' (Lerner, 2006). A more thorough analysis than made here is needed to test these assumptions and this work has not yet been performed.

### **Practical Consequences for Research**

It should be stressed that One Health is not a research topic of its own but a truly multi- and interdisciplinary approach. To carry out interdisciplinary studies, basic disciplines will still be necessary. Furthermore, a One Health approach does not mean that all possible aspects of a certain disease or syndrome have to be included in each and every scientific study. Such an approach would be rather complicated and far from perspicuous. Instead, a more practical approach to One Health implies that the researchers are well aware of any correlations to other species, groups, or ecosystems, and are prepared to include such aspects whenever relevant. Not because they are forced to but because it will simply result in better science.

A One Health perspective might result in more holistic studies, as different perspectives meet when researchers from different backgrounds cooperate. In the case of work places where both animals and humans are involved, a One Health perspective might be an interdisciplinary approach on both humans and animals at the same time. One example is a study called PAWISE, comparing human well-being, animal welfare, human-animal interactions and company efficiency in abattoirs and animal laboratories (Wiberg, 2010 and Wiberg, 2012). (Note here that this label of the project belongs to the opinion of the authors of this paper. No reference to the One Health perspective was made within that study.) Other examples are studies related to occupational health of farm workers who are exposed to microorganisms circulating among the farmed animals in question, and studies looking at the risk of human farm workers introducing pathogens into a herd of domestic animals.

Furthermore, a One Health approach may create a scientific environment where not only laboratory equipment or office space is shared by, for example, physicians, veterinarians, and

microbiologists but where access to samples is shared more generously within the scientific community. In this way, biological samples (be it tissue, blood, fecal samples, effluent water, or anything else possibly relevant), which can be quite difficult, expensive, or ethically complicated to collect, can be used by several different research groups who may be interested in the same – or different – pathogens or toxins, but from different angles. The concept of ‘Open Access Publishing’ has become increasingly popular in a global society where resources are not necessarily evenly distributed. We hypothesize that ‘Open Access Bio Banks’ (though open not to the general public but to relevant research groups) will be an upcoming phenomenon in the era of One Health, where credit is given to the researchers collecting the samples but where the same samples can nevertheless be used for a multitude of scientific purposes. However, the ethical aspects of such data and sample sharing are delicate and must be handled with due care.

A practical graphic approach to use when one discusses interdisciplinarity is to implement an interdisciplinary matrix where one can see where in the research process one holds an interdisciplinary, a biology, a veterinary, or a human medicine perspective. By ticking boxes for each part of the scientific process, the interdisciplinary research group might get a better picture of which part is interdisciplinary and which part is interdisciplinary. This may also contribute to finding new ways to collaborate.

Researchers could mark for different aspects of the research process whether these aspects are interdisciplinary (shared) or stemming from a particular discipline.

### **Practical consequences for education**

The One Health approach can also be applied in a teaching context. When educating and training public health professionals to be, regardless of what university program they have been enrolled into, emphasizing why these different disciplines inherently interact in practice is fundamental. In some parts of the world, it is currently possible to achieve a MSc degree or a PhD in One Health (Gibbs, 2014). There are an increasing number of One Health related textbooks aiming at university students in primarily medicine and veterinary medicine, with a main focus on zoonotic diseases, epidemics and toxicants (Kahn, 2009, Rabinowitz, 2010). Initially, the focus of the One Health discussion appears to have been mainly on food-producing animals, but there is now an increasing interest in illuminating the importance of zoonoses also from a pet ownership perspective, where it is crucial that veterinarians, physicians, and other health care professionals recognize each other’s expertise, a view that is reflected also in higher education (Dvorak, 2013).

Even more radical, there have been suggestions for a whole new education based on the philosophy of One Health. Calvin Schwabe presented a new curriculum that could be implemented as a new education at a veterinary school (Schwabe, 1978 and Schwabe, 1984). Three areas of education were outlined: population, people, and biology (Schwabe, 1984). A more modern attempt to outline a combined education would place these areas, and students, in schools of public health (Kahn, 2011). A risk of establishing such a new curriculum within the established disciplines is that we might experience a similar result as Natterson-Horowitz & Bowers (Natterson-Horowitz, 2013) did when they analyzed One Health and instead proposed the term zoobiguity, that is, that one discipline would be using another one’s knowledge, without any exchange in the opposite direction. Again, the interdisciplinary matrix might be useful to avoid this risk. Schwabe’s argument for placing the curriculum at a veterinary school was

practical. He did not believe it to be possible within a human medical school, despite his own argument from historical studies that real progress seemed to be made when one treated both animals and humans (Lerner, 2013). Following that line of thought, a new curriculum should rather be built up by truly interdisciplinary research departments, and not only by trying to make already existing departments collaborate.

### **Conclusion and Recommendation**

To summarize this paper, one has to keep in mind that the philosophy of One Health still needs to be written. An attempt has been to show that the choice of term for the approach might be normative in deciding which disciplines or parts of disciplines may be included. Then, choosing a definition of health is also a normative task defining what aspects of health is important. This will have practical implications for both research as well as education for research.

## REFERENCES

- Bekoff, M. (1994). *Cognitive ethology and the treatment of non-human animals: how matters of mind inform matters of welfare*. *Anim Welf*; 3: 75–96.
- Boorse, C. (1997). A rebuttal on health. In: Humber, J., Almeder, R., eds. *What is disease?* New Jersey: Humana Press, pp. 3–134.
- Broom, D. M., Johnson, K. G. (1993). *Stress and animal welfare*. London: Chapman & Hall.
- Broom, D. M., Kirkden, R. D. (2004). *Welfare, stress, behaviour and pathophysiology*. In: Dunlop, R. H., Malbert, C. H., eds. *Veterinary pathophysiology*. Ames, I. A: Blackwell, pp. 337–69.
- Callicott, J. B. (1995). Environmental ethics: overview. In: Reich WT, ed. *Encyclopedia of bioethics*. Rev. ed., Vol. 1. New York: Macmillan, pp. 676–86.
- Cannon, W. B. (1949). *Kroppens visdom*. Människokroppens underbara anpassningsförmåga [The wisdom of the body. The wonderful adaptability of the human body]. Stockholm: Natur och Kultur.
- Derrida, J. (2008). *The animal that therefore I am*. New York: Fordham University Press.
- Dhammika, V. S. (1993). *The edicts of King Ashoka*. The Wheel Publication No. 386/387. Available from: <http://www.cs.colostate.edu/~malaiya/ashoka.html>
- Döring, T. F., Pautasso, M., Finckh, M. R., Wolfe, M. S. (2012). *Concepts of plant health - reviewing and challenging the foundations of plant protection*. *Plant Pathol*; 61: 1–15.
- Dvorak, G., Roth J. A, Gray, G. C, Kaplan B, editors. (2013). *Zoonoses - protecting people and their pets*. Ames, IA: Centre for Food Security & Public Health, Iowa State University.
- Fletcher, J., Franz, D., LeClerc, J. E. (2009). *Healthy plants: necessary for a balanced 'One Health' concept*. *Veterinaria Italiana*; 45: 79–95.
- Gibbs, E.P.J. (2014). *The evolution of One Health: a decade of progress and challenges for the future*. *Vet Rec*; 174: 85–91.
- Gibbs, E.P.J., Anderson, T. C. (2009). *'One World - One Health' and the global challenge of epidemic diseases of viral aetiology*. 45: 35–44.
- Gluckman, P., Beedle, A., Hanson M. (2009). *Principles of evolutionary medicine*. Oxford: Oxford University Press.
- Gunnarsson, S. (2006). *The conceptualization of health and disease in veterinary medicine*. *Acta Vet Scand*; 48: 20–5.
- Jakobsson, C. (2012). Definitions of the ecosystems approach and sustainability. In: Jakobsson C, ed. *Sustainable agriculture. Ecosystem health and sustainable agriculture 1*. Uppsala: Baltic University Press, pp. 13–5.
- Kahn, L. H., (2009). *Who's in charge - leadership during epidemics, bioterror attacks, and other public health crises*. Santa Barbara, CA: ABC Clio.
- Kahn, L. H., (2011). The need for one health degree programs. *Infect Ecol Epidemiol*; 1: 7919, doi: <http://dx.doi.org/10.3402/iee.v1i0.7919>.

- Krebs, S., Danuser, J., Regula, G. (2001). *Using a herd health monitoring system in the assessment of welfare*. Acta Agric Scand A Anim Sci Supplementum; 30: 78–81.
- Lerner, H. (2013). *The philosophical roots of the 'One Medicine' movement: an analysis of some relevant ideas by Rudolf Virchow and Calvin Schwabe with their modern implications*. Studia Philosophica Estonica; 6(2): 97–109.
- Lerner, H. (2008). *The concepts of health, well-being and welfare as applied to animals*. A philosophical analysis of the concepts with regard to the differences between animals. PhD thesis, Linköping University, Linköping.
- Lerner, H. (2012). *Virchow*. In: Nordenfelt L, ed. *Filosofi och Medicin: Fran Platon till Foucault* [Philosophy and medicine: From Plato to Foucault]. Stockholm: Thales, pp. 135–50.
- Lerner, H. Hälsa som balans. (2006). *Health as balance*. A critical review of a central concept in medicine and veterinary medicine. Essays on health. An anthology from the research education at Theme Health and Society. Linköping: LiU-Tryck, Linköpings Universitet, pp. 33–44.
- Natterson-Horowitz, B., Bowers, K. (2013). *Zoobiquity: the astonishing connection between human and animal health*. New York: Vintage Books.
- Nordenfelt, L. (2006). *Animal and human health and welfare: a comparative philosophical analysis*. Wallingford, UK: CAB International.
- Rabinowitz, P. M., Conti L. A. (2010). *Human-animal medicine - clinical approaches to zoonoses, toxicants and other shared health risks*. Maryland Heights, MI: Saunders Elsevier.
- Rapport, D. J., Bohm, G., Buckingham, D., Cairns, J., Costanza, R., Karr, J. R. (1999). *Ecosystem health: the concept, the ISEH, and the important task ahead*. Ecosys Health; 5: 83–90.
- Ruhli, F. J., Henneberg, M. (2013). *New perspectives on evolutionary medicine: the relevance of microevolution for human health and disease*. BMC Med; 11: 115.
- Schwabe, C. W., (1978). *Cattle, priests, and progress in medicine*. Vol. 4. Wesley W Spink lectures on comparative medicine. Minneapolis, MN: University of Minnesota Press.
- Schwabe, C. W., (1984). *Veterinary medicine and human health*. Baltimore, MD: *The Williams & Wilkins*.
- Stearns, S. C., Koella, J. C, (2007). *Evolution in health and disease*. 2nd ed. Oxford: Oxford Scholarship Online.
- Trevathan, W. R. (1995). *Evolutionary medicine: an overview*. Anthropol Today; 11(2): 2–5.
- Wiberg, S., (2012). *Slaughter - not only about animals*. An interdisciplinary study of handling of cattle at slaughter. Licentiate thesis, Thesis 5, Department of Animal Environment and Health, Swedish University of Agricultural Sciences, Skara.
- Wiberg, S., Algers, B., Gamble, A., Gunnarsson, S., Garling, T., Hultgren, J. (2011). *Welfare of animals and employees in connection with slaughter or euthanasia of animals*. In:

Proceedings of new paradigms in laboratory animal science. A joint FELASA/Scand-LAS Symposium. Helsinki, Finland 2010. pp. 148–52.